Time-Synchronized Beacons for Relative UAV Position Determination

Completed Technology Project (2016 - 2017)

Project Introduction

Research is required to determine the optimal pulse length, pulse frequency, pulse power, and optical communications encoding technique to meet FAA and STMD separation requirements and to demonstrate the concept of time-synchronization of beacons using GPS for clock calibration. Milestone 1: GPS-Synchronized Clock Concept ValidatedThe ability to independently synchronize high-precision clocks at multiple different spatial locations using GPS as the synchronization source will be experimentally validated.Milestone 2: Tier 1 Analytic Study ResultsAn analytic study will be used to determine the optical receiver sensitivity and noise floor required to achieve acceptable signal-to-noise levels for range determination and for optical communications as a function of vehicle separation, transmitter beam divergence, and receiver field of regard. The analytic study will also address whether a simple sensor can meet the system requirements or whether an approach such as a laser heterodyne receiver will be required. Milestone 3: Tier 1 Analytic Study ValidatedThe predictions of the analytic study will be experimentally validated to the extent permitted by time and budget.Switching over to optical communications instead of RF communications has the potential for revolutionary reduction in SWaP. By using either laser diodes or high-intensity LEDs as transmitter beacons, even small USAVs should have the ability to broadcast their location. Receivers for the beacon information can be either high-speed optical sensors that provide range and optical communications or multi-function cameras that provide terrain and non-cooperative target information in addition to functioning as the beacon receivers. The major innovation is the use of GPS signals to synchronize the clocks for the transmit and receive portions of the beacons. Using GPS, clocks can now be synchronized to within 10 nanoseconds. By having all of the beacons transmit at the same time and at the same interval, the light arriving from other spacecraft/aircraft can be used to measure azimuth, elevation, and range to the other vehicles in the field of view. By modulating the out-going light beacon pulse, information such as vehicle ID (i.e.: tail number for aircraft), position, and heading can also be transmitted for redundancy. This concept could be considered as a bi-static lidar system where every vehicle is both a transmitter and a receiver and the time-of-flight for the beacon pulse to reach the receiver is used to determine the range between the receiver and each of the transmitters in the field of view. Other than the revolutionary use of time-synchronization for the beacons, this represents an evolutionary step for free-space optical communications. The use of time-synchronized beacons to enable bi-static, multi-platform, lidar range measurements is believed to be unique to this effort.

Anticipated Benefits

Autonomous Unmanned Spaceborne and Airborne Vehicles (USAV) require the ability to maintain separation from other spaceborne and airborne vehicles. The currently approved technologies to do that for aircraft do not meet Size,

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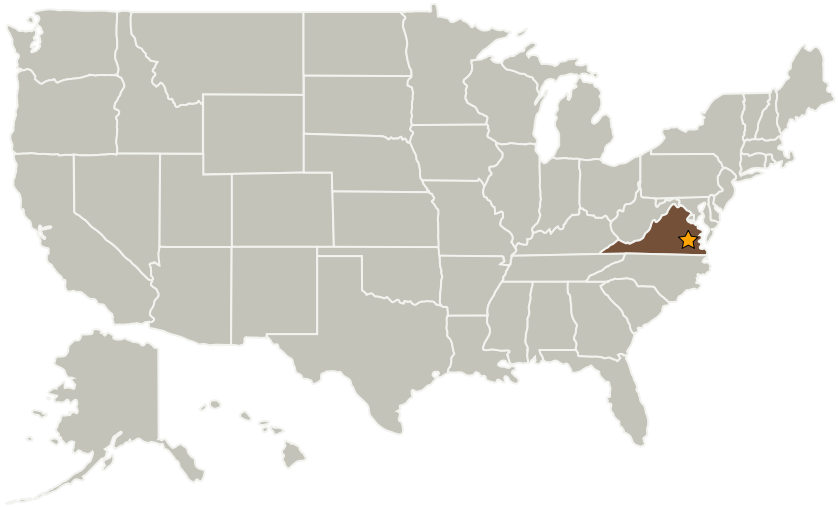
Weight, and Power (SWaP) requirements for use on small Unmanned Aircraft System (UAS) and they do not generalize for use by spacecraft. This effort seeks to develop an optical communications beacon concept to enable USAVs to meet separation requirements, to provide relative vehicle position information, and to provide optical communications between the vehicles.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Langley Research Center(LaRC)	Lead Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations
Virginia

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Langley Research Center (LaRC)

Responsible Program:

Center Innovation Fund: LaRC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

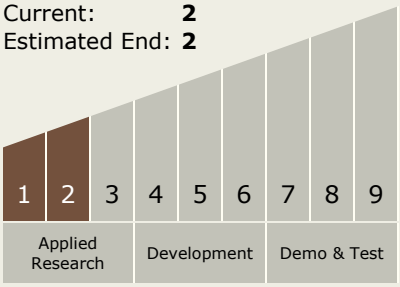
Julie A Williams-byrd

Principal Investigator:

Ivan O Clark

Technology Maturity (TRL)

Start: **1**
Current: **2**
Estimated End: **2**



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Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.3 Human Health and Performance
    - TX06.3.2 Prevention and Countermeasures

Target Destination

Earth